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TRAUMATIC NEURALGIA;

SECTION OF MEDIAN NERVE.

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[WITH FIVE WOOD-CUTS.]

MISS T. at the age of two and a half years ran a splinter into the palm of the right hand over the point at which the median nerve divides in order to send branches to the thumb and fingers. The fragment, which came from a barrel hoop, was said to have been, when it entered, a third larger than when taken away twenty years after. It passed so deeply into the hand that it was thought best to poultice the part and encourage suppuration before removing the foreign body. To the physician's surprise the wound healed rapidly, every sign of irritation passed away, and the child soon after was taken from this city, in which the accident took place.

The piece of wood could always be felt distinctly in the palm, but only once, when in Panama, at the age of twelve, was its presence in the least degree annoying. When 22 years old, Miss T., then in Naples, caught hastily the falling top of a trunk, and in so doing bruised the region in which lay the splinter. Great local pain and slight swelling followed, but, growing better in a few days, left her with some uneasiness and discomfort in the part struck. After three months she began to have pain in the right shoulder, for which Dr. Suchet, of Paris, ordered liniments, regarding it as rheumatic. In May of the same spring of 1871, the pain in the hand grew worse, and in July it was severe in the median palm, thumb, and palmar face of the index-finger. At Plombières, in August, and later while travelling, it increased, and extending to the forearm assumed throughout a hyperæsthetic character, so that she began to guard the parts from foreign touch. It now became plain that the trouble was due to the splinter, and accordingly, at Milan, October 22, 1871, Dr. Sapolini, Surgeon to the King of Italy, assisted by Dr. Guerini, after a careful search removed the splinter, which is said to have lessened in size, is certainly smoother than it could have been at first when twenty years before it entered her palm. Dr. Sapolini, whom I had the pleasure to meet in Milan last summer, told me that it lay among the diverging median nerve filaments, and was taken away with great difficulty. On awaking from the chloroform sleep, she was at once conscious of intense

pain in the fore-finger and thumb. Within a few days the fingers contracted in firm flexion, the pain became exquisite, a touch was torture, and the median palm from time to time swelled and throbbed so as to induce the belief that pus had formed. Under poultices it would, however, subside, and in a few days go through the same process anew. The wound healed in a month, but thenceforward she lived under the influence of morphia, being almost entirely sleepless from the incessant pain and exquisite hyperalgesia which made the lightest contact a thing to be guarded against by precautions which seemed almost absurd. Despite the pain, a successful effort was made to straighten the fingers by the aid of a dorsal splint, and on its removal they remained straight or extended. The torment was worst on the thumb, median half of face of forefinger, the annulus, and the median palm close to the forefinger. It also extended on to the back of the hand, where it affected the dorsal surface on the radial side of the hand, and especially the last two phalanges of the second and third digits where the pain was no less than in front. Throughout all the regions named it was a constant burning pain, with red and smooth surfaces upon which the fall of a bit of lace or a veil edge was simply anguish.

In this condition Miss T. went from one well-known physician to another, the pain passing up the forearm and involving its whole surface in a hyperalgesia which varied in degree and was accompanied with a disturbance of the local circulation in the limb, so that it was now intensely flushed and now pale in spots. The shoulder also continued to be painful, and associated neuralgias awoke in the right face and neck and even in the right foot.

The whole range of usual local and general therapeutic means failed to lessen her pain, although heat, cold, actual cautery, Vienna paste, hypodermic injections of morphia, blisters, electricity (induced currents) were employed in turn, with an endless list of others which I need not catalogue. At length, in November, 1871, Dr. Sapolini found, after the most careful study, that, while protracted pressure on the median nerve in the forearm caused only an increase of pain, pressure on the musculo-spiral, at first increased and by and by destroyed not only the pain but the sensitiveness so completely that the finger and thumb could be roughly handled both on their dorsal and palmar faces. Again and again he applied this test, and when fully convinced that he was not mistaken and that relief always followed the pressure, he cut down on the musculo-spiral nerve above the outer side of the elbow and removed an inch of it. Absolute ease at once followed this section, pain and sensitiveness alike disappearing, while, to the amazement of the skilful anatomist who operated, the loss of touch in the radial regions of the back of the hand was so slight that he doubted there being any loss, although a considerable amount of wasting in the extensors and an absolute wrist-drop showed that the muscular distribution of the nerve had suffered. The full extent of this loss I have not learned. It left for a time a hollow in the forearm, but within a few months (four or five) the arm regained its plumpness, and as to the lack of power in the extensors it was certainly slight in the spring of 1873, although at this time the pain was enough to so far inhibit movement as to make it no easy task to judge of the real amount of motility. As to the sense of touch being but slightly hurt anywhere in the hand by the section of the musculo-spiral, I have also the assurance of Miss T., whose curiosity led her to examine the part with care.

On the eighth day after the operation the pain suddenly returned. The

sensitiveness to touch remained somewhat lessened on the back of the fingers and thumb, and on the whole the torture was thereafter less extreme, but it was still terrible, and the associated sensations grew worse, so that, as I have many times seen in other cases, the whole skin grew irritable and the sources of torment multiplying, bright lights and sharp sounds increased the pain, sensitive spots were developed on the scalp, a thick crop of herpetic eruptions covered the right arm, neck, and face, while the general health began to fail despite the most careful and skilful efforts to sustain it. Something was due no doubt to the prolonged healing of the wound, which was interfered with by frequent abscesses, and at last at the third week by erysipelas.

After the failure to gain full relief from Dr. Sapolini's well-considered operation, Miss T. consulted very many surgeons and physicians of distinction, but without obtaining any further good result. In August, 1872, after using by Sir James Paget's direction a long series of hot water arm-baths, Miss T., by his advice, returned to America. In January, 1873, I saw her in New York, and in the middle of February she placed herself under my care in Philadelphia, where, with the kind aid of my friend Dr. Wm. W. Keen, I made the following notes of her case.

At this time, with no notable functional trouble, Miss T. was thin and weak and singularly liable to sudden flushes or as sudden pallor. She slept with the hand propped upon its ulnar edge, and awakened many times at night when it fell over or was touched by the bedclothes, while all day long she devoted herself to the task of shielding the part from every foreign contact. This anxiety to avoid having the hand touched, and the constant influence of pain, gave to her physiognomy a singular expression of suffering and vigilance, such as I have rarely seen since the terrible traumatic neuralgias of the late war.

The arm presented numerous marks due to the use of cauteries, and on the palm at the edge of the thenar eminence was the scar of the operation for removal of the splinter, and above the elbow was the cicatrix left by that of the nerve section.

*Motility.*—Miss T. can use the deltoid, and flex and extend the arm, but, if the movement be sudden or extreme, it causes pain in the shoulder and neck. She can slowly and with pain pronate and supinate the forearm. She cannot extend the wrist, but on its being extended can delay its fall, chiefly by using the radial extensors. Slight power to flex wrist. The first and second fingers have no motility; but she can stir the last joints of the other fingers in flexion and extension. Probably most of this lack of power is due to long disuse and the inhibitory power of constant pain. The future history proved this view to have been correct.

*Sensation.*—This was examined by nerve regions. Touch and power to localize or place a touch are normal in the musculo-cutaneous distribution. Touch is well felt above scar left over the point of section of the musculo-spiral. Touch just below the scar is badly felt, and is referred above the scar. The radial and median sensation in the arm is normal, as well as that of the internal cutaneous nerve. In the radial area on the back of the thumb and first and second fingers touch is referred correctly, and is everywhere felt; but throughout this region every touch is felt as both touch and pain. In a less degree this is true of certain parts of the whole arm, and most notably of parts just around the scar of the operation on the musculo-spiral. The ulnar territory is in all respects healthy by compass points. The sensitiveness of the thenar eminence is not acute, but increases as we approach the index-finger. The hyperalgesia is exquisite in the face of the second

finger, and the radial side of the third finger; on the face of the thumb and the palm; over the first joint of the index. In these regions touch is so much more distinctively felt as pain that the degree of health of the power of touch cannot be thoroughly studied. The over-sensitiveness is worst in parts of the median and radial territory of the hand, better in the external cutaneous branches of the musculo-spiral, and normal in the ulnar and internal cutaneous.

The great nerve tracks are tender upon deep pressure, which, over the median and musculo-spiral above the scar, causes increased pain in the hand. The axillary and brachial plexus are also tender, as well as the three upper cervical vertebrae. At times the surface of the right chest is sore, and also the teeth of the right side of both jaws, the teeth being themselves sound.

*Secretions.*—The median palm sweats incessantly, and the odour of the perspiration is very acid and heavy.

*Nutrition.*—The measurements of the two arms are as follows:—

Left forearm	:	:	:	:	:	:	8 $\frac{3}{4}$ inches
Right	"	"	"	"	"	"	8 "
Left arm biceps	:	:	:	:	:	:	9 $\frac{1}{2}$ "
Right	"	"	"	"	"	"	8 "

There is at this date no especial wasting of any of the forearm muscles, and no remarkable want of muscular tone. The interosseal groups are not wasted.

The two little finger nails are normal and alike, the second finger and thumb nails on the right hand are curved laterally, that is, singularly arched. The right index nail is  $\frac{5}{16}$  inch broad, that of the left  $\frac{7}{16}$  inch. She thinks there has been no difference in the rate of growth. The general tint of the right hand is livid, and the arm is liable to sudden alternations of feeling as to temperature, while the slightest irritation causes at first intense paleness followed by definitely limited islands of deeply flushed skin. The skin of the thumb and index-finger is rough, ragged, and marked with yellowish patches of loosened epithelium.

*Temperature.*—I made, at this time, an effort to ascertain the temperature of the affected parts, but totally failed, owing to the sensitiveness of the surface being such as to forbid the mere touch of the instruments.

*Galvanism.*—The forearm and hand muscles all reacted rather feebly under induced currents, but this was possibly due in some degree to long inaction, and she could not endure a severe use of the battery. The effects of galvanism were most interesting, and such as at first to induce me to believe that the constant current might prove of curative value. A current of at least ten cells *in either direction* along the track of the median nerve rendered the fingers nearly altogether free from over-sensitiveness, and enabled me, while the current passed, to ascertain that the sense of touch in these parts was but slightly impaired. This experiment was made again and again with the same result, and satisfied me that the nerve could not be very gravely altered. I am not aware of any like observation elsewhere recorded. I may add that the influence was limited to the median, and that continued galvanic treatment failed to relieve, except at the moment, and this is in accordance with all my former experience of traumatic neuralgia.

A long and careful study at last satisfied me that the cause of trouble lay in the disordered filaments of the median nerve in the hand, and that the effects exterior to this part were probably due to disturbances of the sensorium, propagated from the hand and resulting in associated neuralgias,

such as are commonly but inaptly termed reflex. One question remained to be answered, How far up the median nerve had the organic changes travelled. To this I could give no positive reply, since the whole nerve was tender, and there might possibly be a sclerotic condition of the entire nerve up to its spinal origin; but in this case I should have expected to find the muscles less sensitive to induced currents and the tactile sense greatly disturbed, which was not the case; I therefore determined to take the risk and divide the median nerve. At this stage Dr. Brinton saw the case, and, in consultation with Dr. Keen, we determined to operate on the forearm below the point at which the motor filaments are given off to the forearm muscles. The only loss would thus be the sensibility of the median territory in the hand and the mobility of certain thumb and interosseal muscles. I add here Dr. Brinton's account of the operation, which was done by him with the assistance of Drs. W. W. Keen and Wharton Sinkler.

"March 2d, 1873, I first ascertained precisely the margins of the flexor carpi radialis and palmaris longus muscles by extending the hand upon the forearm. I then made an oblique incision  $2\frac{1}{2}$  inches long, from over the border of the first to that of the last-named muscle; the lower end of this incision terminated two inches above the line of the wrist-joint.

"The superficial fascia and the muscular aponeurosis were next divided on a director in the line of the cut. The tendinous edge of the radial flexor and the narrow tendon of the palmaris were thus exposed to view. I then sought for the median nerve in the inter-muscular space, and uncovered it at the lower end of the cut, just at the point at which it emerges from beneath the oblique fleshy fibres of the flexor sublimis digitorum; with the end of the finger this muscle was then raised from its bed (without laceration of its fibres) as high as the upper end of the incision. The median nerve was thus completely exposed for an extent of  $2\frac{1}{2}$  inches.

"It was decided by Dr. Mitchell that the removal of three-quarters of an inch of the nerve would be sufficient for the object of the operation; and this length of nerve was accordingly excised with the scissors. It was at the same time suggested, that, to diminish the probabilities of reunion of the divided nerve ends by fresh nerve development, the lower exposed end of the nerve trunks should be turned in a transverse direction into the surrounding tissues and there fixed. This was accordingly done, the nerve end being retained in its new position by a wire suture, which was removed at the expiration of forty-eight hours.

"The portion of nerve thus excised commenced below the origin of the muscular and anterior interosseous branches, and terminated above the origin of the palmar cutaneous branch. There was no bleeding; and no ligatures were required. The wound healed in about ten days."

The nerve ends retracted at once to such an extent that, although but three-quarters of an inch were taken away, the separation was found to be an inch and a half, and this became fully two inches and a quarter, when, at my suggestion, the lower end of the nerve was doubled on itself. The nerve looked healthy; and the piece put in Muller's fluid was studied within a few hours by Dr. Bertolet, whose statement I append. A hypodermic injection of morphia was given; this drug caused alarming prostration, while chloral produced the wildest excitement. The wound was painful; and on the third day, in this, as in Dr. Sapolini's operation,

erysipelas came on. It involved the lips of the wound first and thence journeyed to the finger tips and up the arm and over the right side of the chest. During this period of eight days I tried and gave up in turn many forms of narcotics. From this time the case progressed favourably, needing no treatment save tonics and a bountiful diet. A few hours after the operation I made an examination of the limb as well as the pain in it permitted, and found that the palmar face of the thumb and index were insensible, and could be touched without any annoyance, but hyperæsthesia still existed in the radial territory. On the sixth day there were acute pains in the index and thumb, due, I suppose, to the changes in the centric end of the cut nerve. On the sixteenth the hand and arm admitted of a careful study, and we found the following condition :—

*Motion.*—The relief from pain enabled her to move all the muscles save those damaged by the section of the nerve. The flexor tendons tied fast by the cicatrization of the wound, yielded to carefully conducted passive motion, and we shortly learned that the extensors and flexors were in nearly equally good order, but that in the thumb and index there were subacute joint lesions, which promised for a time to limit the range of motion. The section of the median nerve disturbed no muscles save those of the thenar eminence and the median interosseal groups ; but as one of the short adductors of the thumb is fed by the ulnar nerve, there yet remained the power to approximate the thumb and fingers.

*Sensation* was absolutely lost for *touch* and *pain* on the palmar face of the thumb, index, and up to an irregular line on the radial side of the centre of the same face of the third finger. It was not lost on the palm though slightly lessened, but was absent on a part of the dorsal ends of the second and third fingers. Beyond these regions, as I shall further describe, touch was dulled over a much wider range. The area of absolute loss of feeling is seen at a glance in the accompanying diagram. It was traced again and again with the most sedulous care, and each time recorded on diagrams which were found to agree. With no less care I studied the sensory condition of the radial region. At first it presented the hyperæsthesia which had never left it since eight days after the operation on the musculo-spiral, but from the date of section of the median this very rapidly lessened, and within a month was but trifling. The sense of touch in this region was perfect.

The associated neuralgias and the tenderness of the nerves faded with equal rapidity, and thus within ten days, except the relics of radial sensitiveness, there was absolute freedom from every form of pain.

*Nutrition.*—The acneous eruption passed away with the pain, and a marked and steady change for the better took place in the colour and vascular state of the limb.

All the nails of both hands were stained on the day of the nerve section. Those of the left grew steadily at the rate of about 1 mm. a week. *None* of the nails on the right hand grew until the 14th day, when all grew at equal rates.

*Temperature.*—The sensitiveness before the operation, and the erysipelas after it, unfortunately interfered with my earlier thermal studies.

14th day. No erysipelas, wound healed.

10 A.M. Right median region	.	.	.	.	.	.	.	96.5
Left	"	"	:	:	:	:	:	91.5
9 P.M. Right	"	"	:	:	:	:	:	96.4
Left	"	"	:	:	:	:	:	92.5

16th day. Erysipelas again appeared on the right shoulder, but faded in two or three days after a fevered and restless night.

Right median thumb	.	.	.	.	.	.	.	92.4
Left " "	.	.	.	.	.	.	.	95.3

19th day. Patient well.

5 P.M. on 1st joint of index; Right median nerve region . 97.6  
Left " " " . 94.

23d day.

Ball of thumb; Right median nerve region.	93
Left " " "	92
Right index	93.5
Left " "	90

A few days later I awakened a subacute arthritis in the metacarpophalangeal articulation of the right forefinger by making too extreme movement. The trouble proved obstinate, and exacted long rest on a splint with repeated counter-irritation by strong solutions of nitrate of silver; but this was the sole drawback, and ever since the hand has continued to improve in motion, while there remains the most absolute freedom from pain.

On the 20th Nov. 1873, ten months after the operation, Miss T. came to Philadelphia again, and gave me a chance to study the peculiarities of her condition at this time.

The forearm muscles *all* responded readily to moderate faradic currents. The essential thumb muscles in the thenar eminence moved under no form of electric stimulus, faradic or galvanic, save the short ulnar adductor, which being fed by the ulnar nerve responded to both currents. The ulnar interossei acted well; the median hand muscles of like groups did not respond to any electric irritation.

*Sensation.*—The study of the sensations proved very interesting. I give the simple details, reserving my comments.

The diagrams of lost touch and pain, made within a month after the section, remain much the same, except that on the median side of the third finger, first and half of second phalanx, touch can now be dully felt. The area of the palm in which touch was marked as lessened, is much as at that date; perhaps has somewhat bettered.

The dorsal regions of lost pain and touch remain as in the diagram, except that on the outside of the thumb there seems to have been some gain.

The ulnar half of the third finger palmar face feels light touch throughout, and correctly refers it, but is incapable of discerning as two the compass points at any distance apart. To my surprise the radial half of the fourth finger, though feeling a touch everywhere, is also unable to discern compass points as two at any distance apart. The ulnar side of the palmar face of this finger is more sensitive near the end; last phalanx the points are felt as two at  $\frac{3}{8}$  of an inch apart; on the sound side as two at  $\frac{1}{8}$  of an inch asunder. The fifth finger gives the same response on both sides of the body, but the patient insists that there is a difference in feeling in favour of the sound side.

There is absolute freedom from pain.

The nails grow alike. The thumb muscles are atrophied.

*Remarks.*—The trouble in this case began when the point where the splinter lay was struck. It is difficult to say what was the nature of the process then set up, but it was certainly irritative in character, and was

suddenly made worse by the operation in which the foreign body was removed. The hyperæsthesia and burning pain, and the contraction of the fingers make it probable that the trouble was inflammatory. The after-consequences were most interesting and instructive. The phenomena of pain and hyperalgesia, at first limited to the median nerve, as usual began to bring about in the sensorium a state of morbid irritability in closely related groups of ganglionic nerve cells, so that the musculo-spiral was next affected, and this, as I have said, through the sensorium; next other centres felt the same influence, and the irritative radiations inward from the diseased median so morbidly altered other and remoter sensation centres, as to cause these also to express pain, and thus to give rise to associated neuralgias of the shoulder, neck, face, and leg, the influence being throughout purely unilateral. When the nerve was divided, the centres were at once relieved from this steady afflux of morbid impressions, and rapidly regained their healthy states, with the exception of those from which arises the musculo-spiral nerve, the radial filaments of which still remain slightly over-sensitive, but are also improving.

In many cases I have traced these associated sensations to a passage upwards of the condition of neuritis or sclerosis, which came at last to invade other nerves of the parent plexus. At present, I believe that I should incline to charge a greater number of these secondary neuralgic and other changes to this singular condition of the centres of sensation, which, under the influence of constant irritation, propagates, from one set of ganglia to another, a growing tendency to evolve pain and other phenomena in the nutritive sphere. We have thus developed at last in the sensory centres a state which elsewhere I have described as being the exact analogue of what strychnia causes in the motor centres. Given such a state of things, and the sensory centres not only feel as pain influences which are not usually productive of pain, but also within themselves originate, as it were spontaneously without new irritations from without, the condition called pain. As yet we know of no drug which can bring about this state of the sensory ganglia, as strychnia causes a like state of the motor organs.

The ease for a time given in all the nerve regions involved by Dr. Sapolini's section of the musculo-spiral must, as I think, have been due to some influence which it exerted on and through the related groups of nerve centres.

In facial neuralgias not traumatic, I have frequently observed that the fits of pain in the infra-orbital could be temporarily bettered or checked by pressing upon the supra-orbital, or that pain in the infra-maxillary could be controlled by hard pressure on the supra-orbital. Sometimes, as I saw to-day in a neuralgia of the jaw in a toothless man, the slightest pressure anywhere on the gum will relieve the pain which talking or swallowing evolves. A sudden impression thus made at any point more remote might

effect a like object. Thus, I am sure that I have seen pain in the brow disappear for days on the removal of a sound tooth, which was not really the agent in creating the pain, and I am disposed to explain thus many of the reliefs or cures of neuralgia by pulling teeth.

Section of the musculo-spiral is said, by Dr. Sapolini, not to have destroyed the sense of touch or pain anywhere in the radial territory of the hand, and if the patient and the operator were not deceived, this is to be attributed to the remarkable manner in which the nerves run over into the territories of their neighbours, and possibly to some variation in the normal supply. The part in question remained unaffected as to feeling by section of the median, so that the repair made *ad interim* must have been very complete.

The usual muscular distribution of the radial to the extensors certainly suffered, but as there is to-day full power, and as the early and marked atrophy has passed away, I conclude that the lost inch of the musculo-spiral has been restored most remarkably. Errors as to sensation may readily be made, but surely none could be as to the palsy and atrophy of the extensors, while also it is well to remember, that although the hand nerves run over, as it were, into one another's territories, the muscles are more constantly supplied by single nerves, and have a far less irregular distribution.

In studying the areas of lost sensation in this most valuable case, I shall first consider the case of touch. Fourteen days after the operation it was as shown in Diagrams 1 and 2. In November, 1873, it had changed but

Fig. 1.

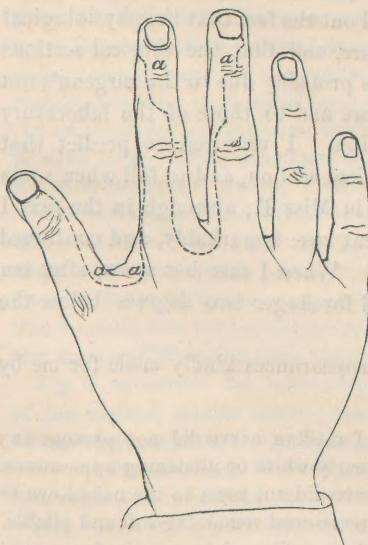
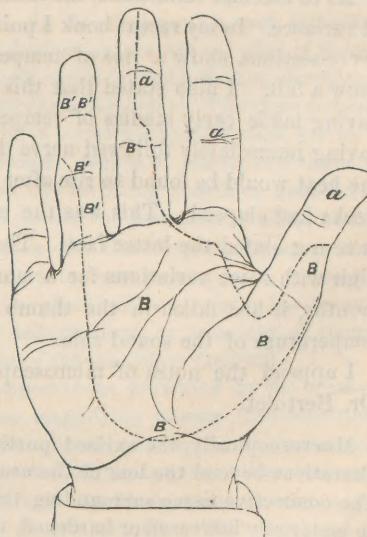


Fig. 2.



*a.* Pain and touch lost. *B.* Touch lessened. *B'.* Touch slightly lessened.

little on the dorsal aspect, while on the palmar face it had altered somewhat, so that, in certain portions of the thumb and third finger, a touch was felt in November where in February it was not.

Perhaps it may be said that the local shock may have been the partial cause of the more complete loss in February, but the change was slight. Something may be due to the greater attention paid to the region of dulled sensation, owing to which the sensorium became trained up to the perception of impressions which at a former period could not be felt at all. The loss of touch and pain was entire in the regions marked.

In a part of the palm, as indicated, pain was not notably less, and touch was slightly lessened, as measured by compass, for in all of the palm marked B, the lightest impact was felt. So also of the touch in the third digit, ulnar side, and all of the face of the fourth. These facts are of interest because the region of the greatest loss, dorsal and palmar, by no means corresponds to the anatomical descriptions and drawings, which either allow us to suppose the distribution to be symmetrical, or delineate it in diagrammatic lines which do not correspond either to the results in this case or in others. The innervation beyond the radial side of the third finger is also seen to be disproportionately small.

In Miss T.'s case there is, too, some loss of function in the ulnar side of the fourth finger for which we are hardly prepared by the usual descriptions.

I had hoped to learn, from this case, whether nail growth is checked by nerve section. Unluckily the facts prove too much, since neither in the ulnar, radial, nor median territories did they grow for some time. Moreover, the presence of erysipelas may have influenced the nail growth.

As to thermal conditions, the laboratory and the clinic have seemed to be at variance. In my recent book I pointed out the fact that the physiological nerve-sections show a rise of temperature, and that the surgical sections show a fall. I also stated that this was probably due to the surgeon's not having made early studies of temperature and to those of the laboratory having immediately followed nerve division. I ventured to predict that the heat would be found to rise after clinical section, and to fall when some weeks had elapsed. This was the case in Miss T., although in the text I have not stated the latter fact. The heat rose remarkably, and continued high with some variations for a month. When I saw her anew, after ten months, it had fallen in the thumb and forefinger two degrees below the temperature of the sound side.

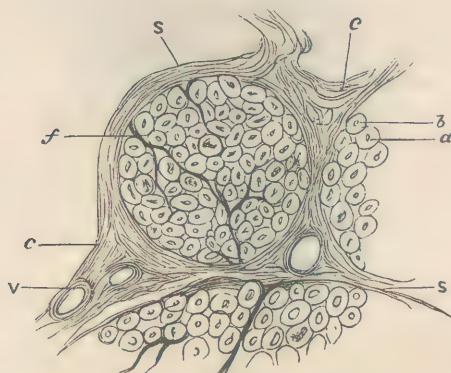
I append the notes of microscopic appearances kindly made for me by Dr. Bertolet.

Macroscopically, the excised portion of median nerve did not present any alterations beyond the loss of the usual pearly-white or glistening appearance. The connective tissue surrounding the nerve did not seem to the naked eye to be materially increased or hardened, the nerve-cord remaining soft and pliable. The nerve was hardened for section by being allowed to remain for several

weeks in a dilute solution of chromic acid. The whole nerve was then imbedded in wax, and transverse cuts made; these were then stained in Tiersch's neutral carmine solution; the water was then abstracted by placing the cuts successively in alcohol and absolute alcohol. They were finally rendered transparent in the oil of cloves, and permanently mounted in Damar varnish.

For the sake of comparison and in order that the description of the alterations presented might be readily understood, we have given in Fig. 3 the micro-

Fig. 3.



*Cross-cut of Fasciculi of a Normal Radial Nerve.*—*a.* Dark spot representing the axis-cylinder surrounded by the hyaline mass or white substance of Schwann. *b.* Medullary sheath or membrane of Schwann. *s.* Sheaths of the secondary fasciculi. *f.* Trabeculae of connective tissue subdividing the fasciculus. *c.* Loose connective tissues in which are seen, *v.* sections of the blood vessels.

scopic appearances presented by a normal radial nerve in the cross-cut when prepared precisely by the same method. In the cross-section each individual nerve-fibre exhibits an external ring with double contour, the cut edge of the medullary sheath, nearly in the centre of each circle is seen a dark spot, which is readily stained by carmine; this constitutes the axis-cylinder. The space between the axis-cylinder and the outer circle is filled up with a hyaline mass, known as myeline or the white substance of Schwann. Septa of connective tissue, as shown in the figure, stretch inwards from the investing sheath or neurilemma of the nerve-trunk and divide it into a greater or less number of secondary nerve-bundles or fasciculi. In the cross-section these septa are seen as thick rings, which are united among themselves by more or less loose connective tissue *c*; in the latter are seen coursing the bloodvessels supplying the nerve *d*. The fasciculi are further subdivided by delicate fibres or trabeculae of connective tissue which spring from the sheaths of the secondary fasciculi.

Fig. 4 represents the microscopic appearances presented by the cross-cut of the excised median nerve; the same magnifying powers (180 diameters) being employed as in the preceding figure. It will be seen that the connective tissue of the sheathing of the fasciculi as well as the interfascicular trabeculae are slightly increased in thickness and quantity, though not to that degree which marks the hypertrophy attending chronic neuritis. The sheaths of the fasciculi have no longer the distinct fibrillated appearance of the first prepa-

ration, but merge into the connective tissue in the vacuity. The individual nerve-fibres themselves, however, present the principal changes. In very few of the rings of the secondary fasciculi, even with the higher powers (*vide* Fig. 5),

Fig. 4.

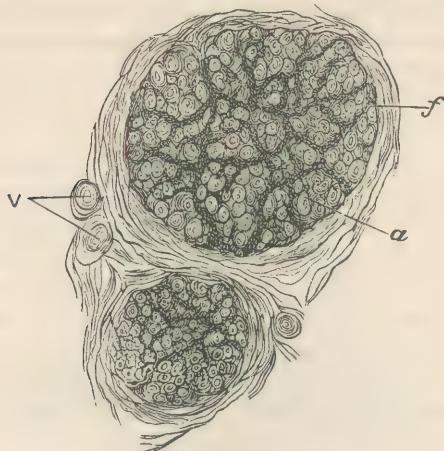
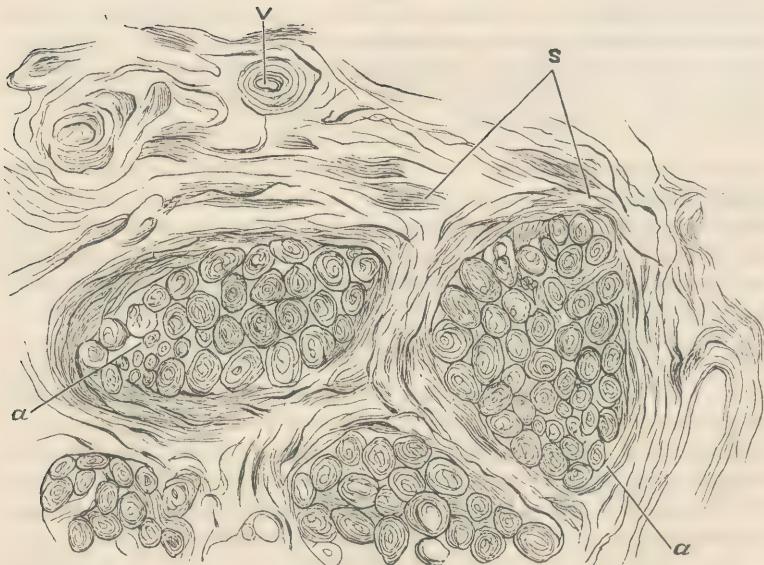


Fig. 5.



FIGS. 4 AND 5. *Cross-cut of Fasciculi of the Median Nerve, exhibiting the Lesions of the Wallerian Degeneration.*—*a.* Confused outlines of the nerve-fibres, concentric arrangement within the circles; scarcely any axis-cylinder to be seen. *s.* Sheaths of the fasciculi. *f.* Trabeculae of connective tissue, moderately thickened. *v.* Bloodvessels, unaltered.

can the axis-cylinder be satisfactorily recognized, nor is it stained by the carmine. The circles of the individual nerve-fibres are no longer clearly de-

fined; they are seen as a confused mass of concentric rings. The myeline is more highly refractive than usual; fresh sections of the nerve, made shortly after its removal, afford a decided play of colours under the polariscope; this property, however, has been destroyed by the process of hardening and mounting employed. Longitudinal sections of the altered nerve revealed a slight increase of the nuclei in the sheaths of Schwann; the latter were no longer homogeneous, but granular and coarsely striated.

The lesions presented in this specimen are those known as Wallerian degeneration; the disintegration and atrophy occurring primarily in the nerve-fibres themselves, while in chronic hyperplastic neuritis the disintegration and atrophy result from the pathological changes occurring primarily in connective tissue framework supporting the nerve-fibres.





